Environmental Lipidomics of Microbial Community Structure and Function

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RESEARCH OBJECTIVES

Phospholipid Fatty Acid (PLFA) analysis has become an interesting and valuable tool for determining the microbial community structure in soils, water, and other environmental samples with complex microbial communities. During PLFA analysis, phospholipids from cell membranes of microorganisms are extracted and used in determining the predominant types of microorganisms in the system, give indications of the physiological status of the microbial community, and also provide a means for estimating the microbial biomass. This type of information is valuable in evaluating changes in community structure and status during remediation or treatment activities, and can also be useful in evaluating the microbial status of natural systems. Our research focuses not only on identifying microbial community structure in the environment, but also applying this technique to look at stress response of pure cultures of metal-reducing bacteria. These bacteria are exposed to stressors in the environment that affect viability as well as the efficiency of metal reduction during the bioremediation processes. Because phospholipids are part of the cell membrane, changes in lipid composition are one of the first phenotypic responses to stress and give insight into cell response and survival mechanisms.

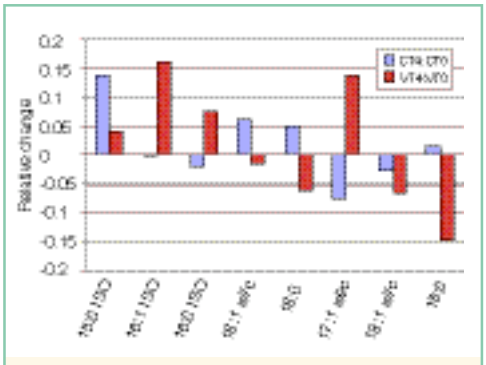

Figure 1. Relative changes in the 8 major types of PLFA after NaCl stress

APPROACH

To determine the lipid response to stress, we grew both *Desulfovibrio vulgaris* and *Shewenella oneidensis* in batch culture and exposed them to a variety of stressors, including cold, heat, pH, salt, nitrate, and oxygen. The phospholipids were extracted from the cultures at different time points to determine how the cell membrane responded to stress and to determine if specific fatty acid patterns can be used as an indicator of phenotypic response to stress analysis.

ACCOMPLISHMENTS

To date, approximately 40 *Desulfovibrio vulgaris* and 5 *Shewenella oneidensis* stress experiments have been completed. The results show that the lipid response is varied and highly dependent on stress conditions and organism type. For example, during salt stress, *Desulfovibrio vulgaris* increases its amount of lipid per cell, and at the same time increases its proportion of saturated lipids (see Figure 1). During oxygen stress of *D. vulgaris*, no growth occurs in the cells, but the PLFA analysis shows also that no significant death occurs, and there is little or no change in the lipid patterns or total amount of lipids in the culture. For *Shewenella oneidensis*, many genes involved in production of saturated and/or branched-chain fatty acids are affected by both temperature and salinity. During salt stress, the cells adapt their membrane fluidity to external conditions by increasing the proportion of unsaturated lipids and decreasing the relative amount of unsaturated lipids.

SIGNIFICANCE OF FINDINGS

This research documents the phenotypic response of cells to environmental stressors. Continued work will be focused on linking the PLFA phenotypic responses to genetic pathways. This research is expected to increase the ability to identify stress responses in environmental samples.

RELATED PUBLICATION

Borglin, S., T. Hazen, D. Joyner, R. Huang, N. Katz, E. Alm, and A. Kazakov, Phospholipid fatty acid analysis as phenotypic indicators of common stress response pathways in *Desulfovibrio vulgaris* and *Shewanella oneidensis*. ASM General Meeting, Atlanta, Georgia, June 8, 2005.

ACKNOWLEDGMENTS

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